Space Weather Technical Forecast

Issued on Sunday, 23 April 2023 at 01:13 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Strong geomagnetic storm/G3 from CME Likely early on Day 2 (Monday 24 April). Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only minor C-class flares. There are currently six numbered sunspot regions on the visible disc. AR3282 in the northwest quadrant is the largest and most magnetically complex, although appears to be stable. AR3279 in the southwest has shown some decay in recent hours. AR3285 continues to rotate around from the limb, although with very little change. All remaining sunspots remain small and stable, including the two new and currently unnumbered sunspot regions on the visible disc. A large full-halo CME from the 21/1812UTC M1.7 flare and associated filament eruption from near centre-disc is due to arrive at Earth at the start of the UTC day of Monday 24 April. No other Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, was initially at slow-ambient levels, before rising to mostly slightly elevated levels, ranging between 370-450 km/s. The solar wind density was below average levels. The IMF was stable at or below 7nT over the 24 hours, while the north-south component ranged between +5/-5nT. The phi angle was mostly negative (towards the Sun) for much of the period, but has recently become positive (away from the Sun). The net effect of the above solar wind measures was Quiet (Kp1-2) geomagnetic activity.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, started the period at background levels, but there was a notable increase in activity following the M-class flare and filament eruption from 21/1812UTC, although levels have remained below the minor storm (S1) threshold. High energy electron flux (greater than 2MeV) as measured at GOES16 was mostly at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on a steady trend, with 2.43e6 integrated pfu observed at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Slight Chance of isolated Moderate activity, mainly due to AR3282 but perhaps also from the AR3285 in the southeast quadrant, otherwise activity is most likely to remain Low.

Solar Wind / Geomagnetic Activity: The large full-halo CME from the 21/1812UTC M1.7 flare and filament eruption is due to arrive either late on Day 1 (23 Apr) or during the early hours of Day 2 (24 Apr). Earth is otherwise in a slightly elevated solar wind regime at present. There is a chance of either CH94 or CH95 (both negative) affecting Earth in the next 24 hours, with solar winds perhaps reaching elevated for a short spell (450-550km/s), although this aspect carries low confidence, and a slower regime could equally persist throughout.

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Met Office Space Weather Technical Forecast

A Strong Geomagnetic Storm/G3 is considered Likely on Monday 24 April from the 21/1812UTC flare and filament eruption. A Minor to Moderate geomagnetic storm (G1/G2) is Expected, and there is some bleeding of these probabilities into neighbouring UTC days.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at Background levels, although there is a slight chance of S1 or greater, mainly due to AR3282. High energy (greater than 2MeV) electron flux is currently at Normal Background levels, with little change expected, although a slight increase is possible later in the period in response to HSS effects. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing trend later in the period- although this may remain suppressed due to on-going CME effects.

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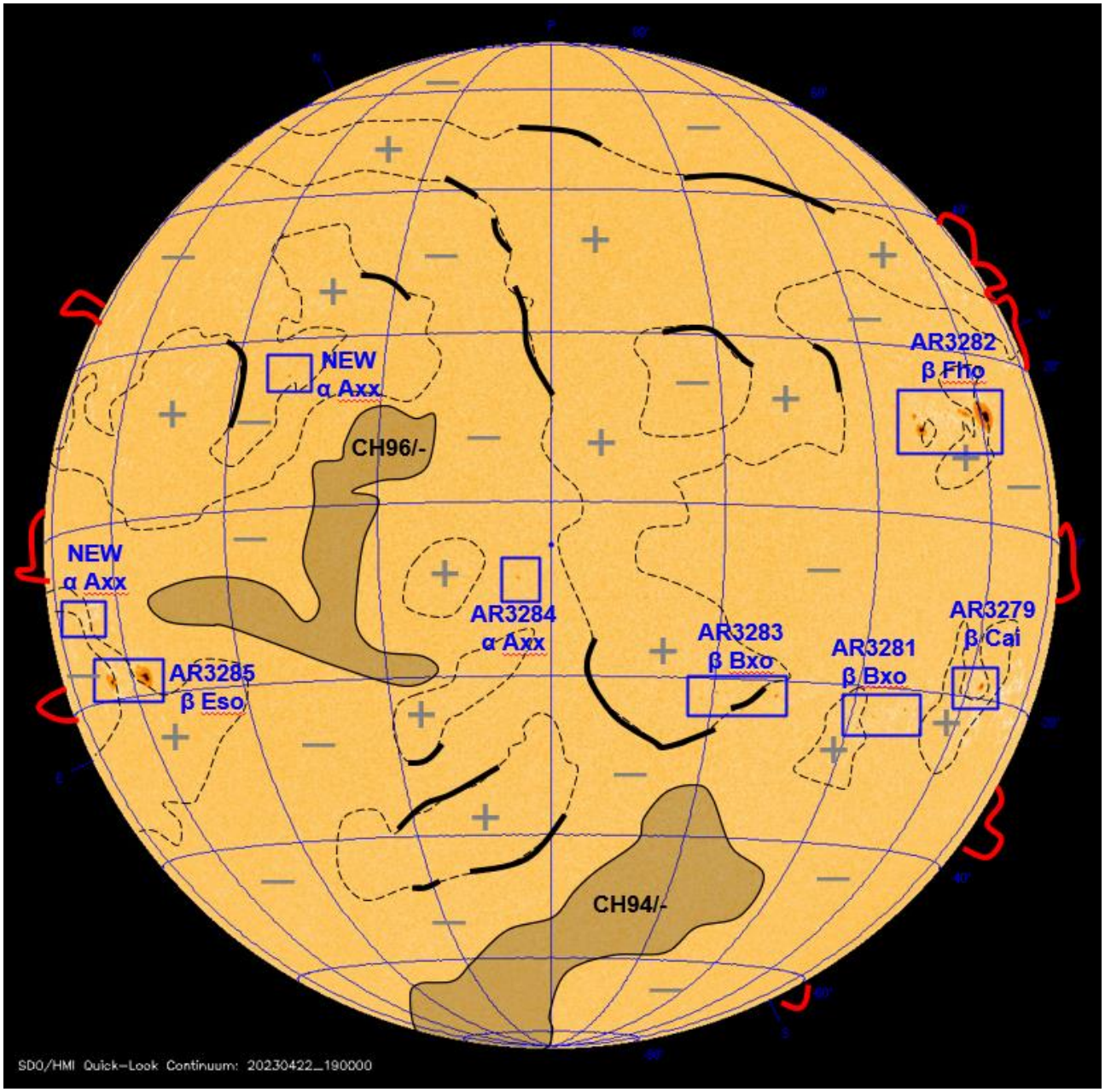
Figure 1. Solar Analysis Valid 22/1900 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The dominant feature of the four-day forecast is the M1.7 21/1812UTC CME from centre-disc. Available imagery for the event is very good, although the very narrow angular difference between STEREO A and Lasco perspectives obviously introduces error bars into the measurement, as does the fact that the CME ejecta itself is rather complex, with numerous lobes of the shock apparently interacting - especially to the northwest of the Sun-Earth line. The main ejecta from this event has been assumed to be that seen heading narrowly southwest, with the CME's angular width therefore significantly impinging on the Sun-Earth line. Earth is currently within a slightly elevated solar wind regime. CH94 or CH95 (both negative) may become geoeffective into Day 1 (23 April) however this is not supported by MOSWOC Enlil, which favours a continuation of ambient conditions. CH94 is a high latitude feature and may pass below Earth, with this feature also smaller and presumably slower than on the previous rotation. CH95 is more centrally located, but had been obscured by sunspot flux to the south and east of it rendering it invisible on latest imagery. Evidence from late last working week of CH95's stature at that time suggests solar wind speeds may reach elevated levels (450-550km/s). A Strong Geomagnetic Storm/G3 is considered Likely either late on Day 1 (23 Apr) or early hours on Day 2 (24 Apr) from the 21/1812UTC flare and filament eruption. A Minor to Moderate geomagnetic storm (G1/G2) is Expected, and there is some bleeding of these probabilities into neighbouring UTC days.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	80	30	10
Strong	G3	No	20	50	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21/2121	Full Halo	Flare/Filament eruption	Centre-West	1081 km/s	24/0200 UTC	Strong Geomagnetic Storm (G3) Likely

Figure 2: Met Office ENLIL model and Ensemble output showing the forecast arrival time of the CME either late on 23 Apr or most likely early hours of 24 Apr.

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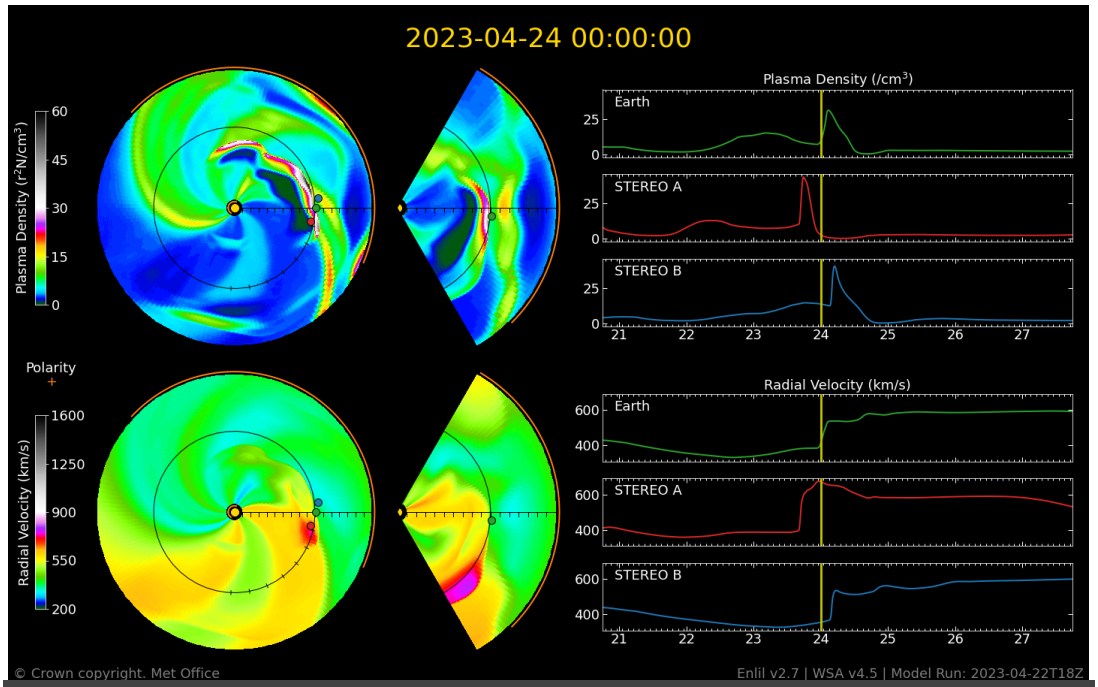

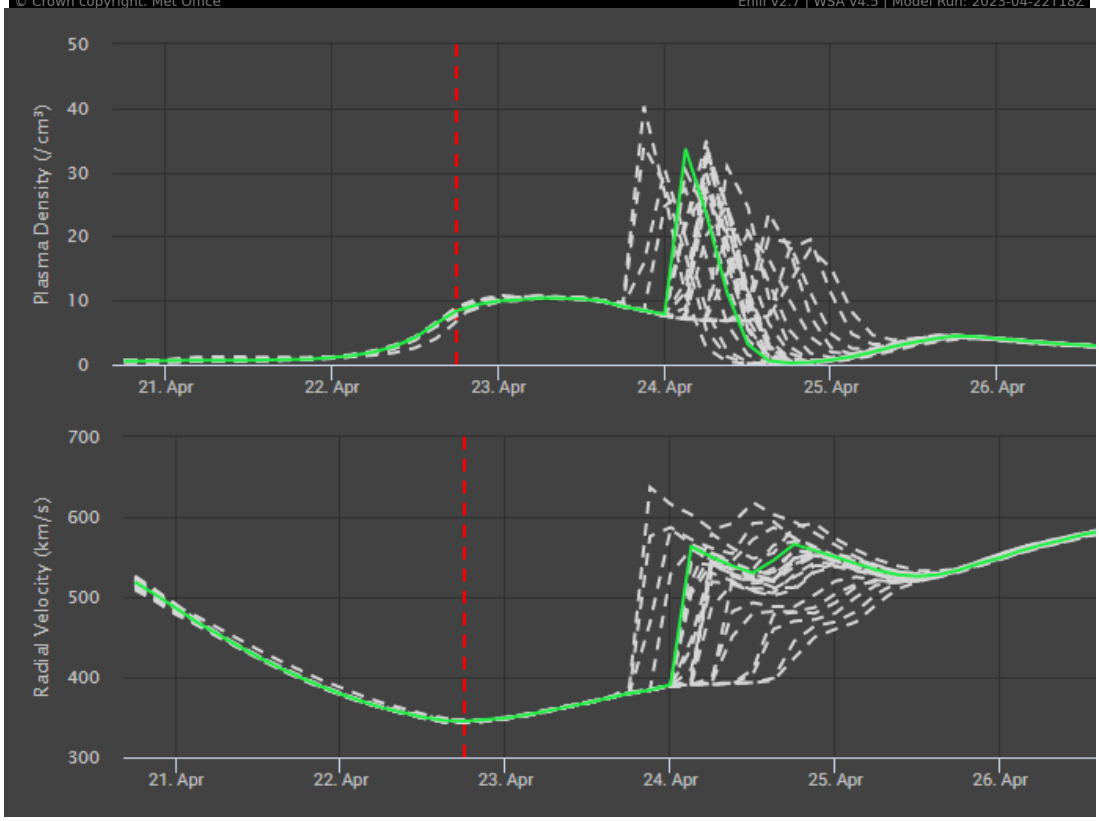

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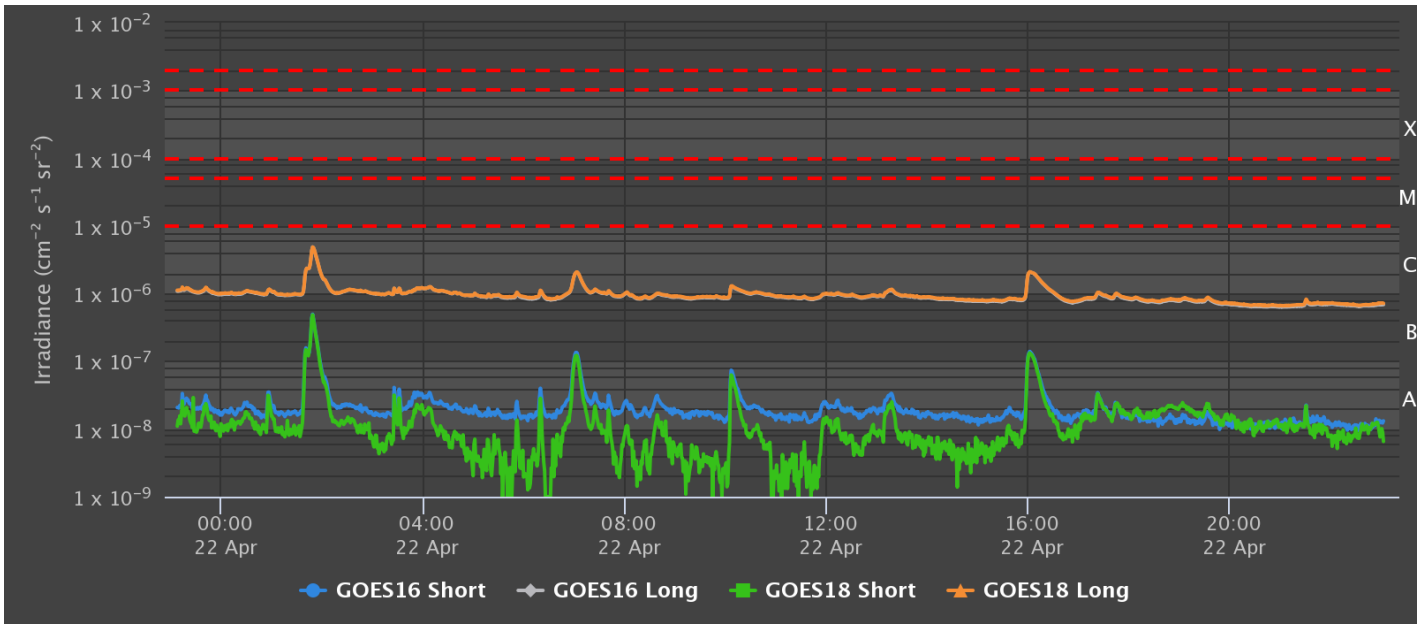
Radio Blackouts - X-Ray Flares:

There are currently six numbered sunspot regions on the visible disc. The largest and most complex sunspot region is AR3282, which is now approaching the northwest limb, although appears to be stable. AR3279 in the southwest has shown some decay. AR3285 continues to rotate around from the limb, with very little change observed. All remaining sunspots remain small and stable, including the two new and currently unnumbered sunspot regions on the disc. At present there is no strong evidence for large eastern solar horizon arrivals, so the Chance of M-class flares is proposed at 30% throughout the coming four-day guidance period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES X-Ray Flares



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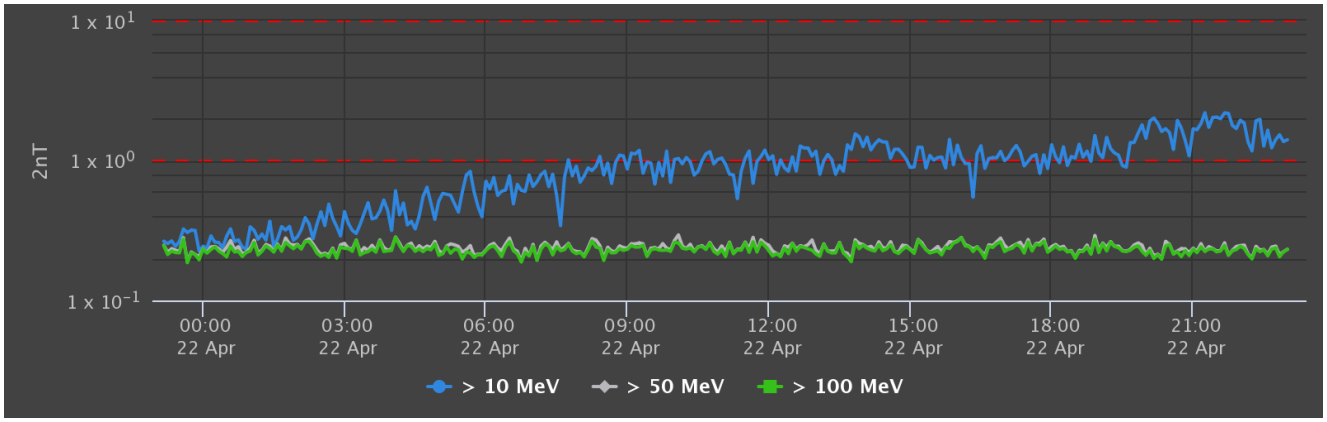
Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV), as observed by GOES16, is currently at Background levels, with a minor response noted in the proton spectrum at GOES16 after the M1.7 flare from near AR3283 on the 21 April. This is reflected by a slight response recorded in lower energies at ACE EPAM LEMS, although there may be other reasons for this (noise or perhaps even the 15 April CME). There is a daily Slight Chance (10%) of reaching S1 or greater, especially should any larger flares occur, with this still thought most likely from AR3282, positioned in a more favourable position, in the northwest quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 Proton Flux – slightly raised after recent M-flare/Filament eruption on 21 April.



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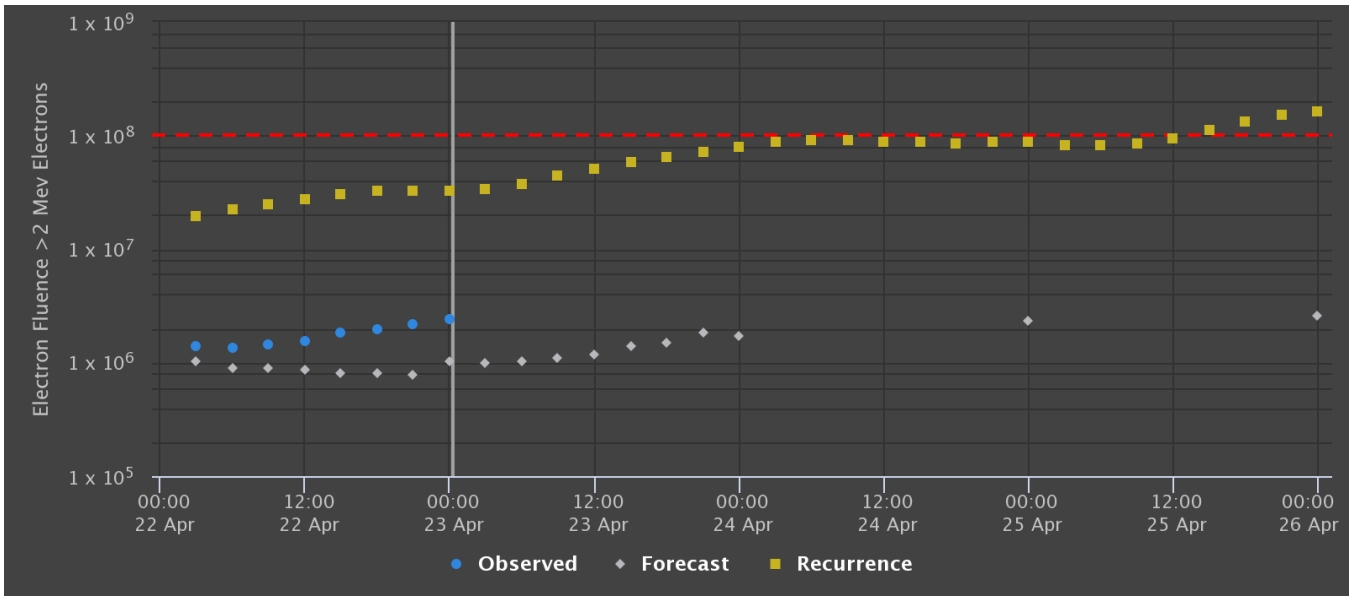
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2MeV) electron flux is currently at Normal Background levels. The most likely drivers of any change to this state of affairs are the twin negative coronal holes CH94/- and CH95/-, however MOSWOC Enlil does not currently support either becoming geoeffective. Should persistence methods prove accurate, a 450-550km/s fast wind may occur, however even this would likely be marginal for electron flux to breach the diurnal High threshold. The chances of 24-hour integrated electron fluence breaching Active are considered Slight during the period, probably reaching a new equilibrium into the new UTC working week, with the caveat that the driving coronal hole fast winds and possibly interrupting CME(s) carry a lowering of confidence.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: REFM electron fluence.



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